HoTT-RO v2

A Mathematical Instrument for Relational Ontology

The Formal System, Its Construction, Application, and Suggested Uses

Waldemar Lis

Waldemar Lis (ontology) | Formal analysis using: Claude (Anthropic)

April 2026

archive.org/details/@not_foryou

Why This Document Exists

Between late 2025 and early 2026, I developed a mathematical formalization of the relational ontology proposed in *The Self-Experiencing Universe: A Manifesto for an Emergent Reality* (Lis, 2025). The formalization used Homotopy Type Theory (HoTT) as its base language, extended with modifications tailored to the ontology's specific commitments. The resulting system — **HoTT-RO v2** — served as the formal foundation for the Vector Consciousness Prediction (VCP) framework, thirteen baseline simulations, six dynamics validation simulations, and a central falsifiable prediction about cuttlefish metacognition.

Three documents already exist describing aspects of this mathematics: a Version 1 formalization, a Version 2 revision, and a general-reader explanation of why HoTT was chosen. What does not exist is a document that presents **HoTT-RO v2** as a self-contained formal system — with its primitive objects, its axioms, its rules of inference, its derived definitions, and the full deductive chain from axioms to empirical prediction. Nor does any existing document ask: where else might this system be useful?

This document fills that gap. It is written for a reader who knows what an axiom system is. It presents **HoTT-RO v2** the way any formal system should be presented: from the ground up.

• • •

Part One: The Formal System

Every formal system consists of primitive objects (undefined terms), axioms (statements accepted without proof), rules of inference (how new statements are derived), and derived definitions (terms built from the primitives). This section presents each layer of **HoTT-RO v2** in that order.

1.1 Primitive Objects

HoTT-RO v2 inherits its primitive objects from Homotopy Type Theory (Univalent Foundations Program, 2013). The undefined terms — the starting vocabulary that is not defined in terms of anything else — are:

Type. The fundamental notion. A type is not a set of elements — it is a space of constructions. To say that a term `a` inhabits a type `A` (written `a : A`) is to give a proof or demonstration that `a` can be constructed as an element of `A`. Types correspond to homotopy spaces in topology.

Term. An inhabitant of a type. A term is a concrete construction. In the ontology, terms correspond to specific relational configurations — a particular octopus, a particular bee swarm, a particular human at age 28.

Judgment. A meta-level assertion about types and terms. The four judgment forms are:

```
a : A          (a is a term of type A)
A : Type       (A is a type)
A ≡ B          (A and B are definitionally equal)
Γ ⊢ J          (judgment J is derivable in context Γ)
```

Universe. A type whose terms are themselves types. Universes are organized in a cumulative hierarchy: $U_0 : U_1 : U_2 : \ldots$ No universe contains itself (this avoids Russell's paradox). This hierarchy is a structural feature of HoTT that **HoTT-RO v2** inherits — and which the Axiom of Flat Mutuality specifically addresses.

Identity type (path). For any type `A` and terms `a, b : A`, the identity type `Id_A(a, b)` is the type of paths from `a` to `b` in the space `A`. Identity is not a binary fact. It is a type — it can have zero, one, or many inhabitants (paths). This is HoTT's most radical departure from classical mathematics.

Note on what is NOT primitive: relations, configurations, consciousness, stability, integration, recursion — none of these are primitive in **HoTT-RO v2**. They are all derived definitions built on the primitives above. This is important: the formal system starts from pure type-theoretic vocabulary and constructs the ontological vocabulary step by step.

1.2 Inherited Apparatus from Standard HoTT

HoTT-RO v2 inherits the full apparatus of standard Homotopy Type Theory. The key constructions used in this project are:

Type constructors

```
Dependent product:   Π(x : A), B(x)
  — for each x:A, a term of type B(x)
  — corresponds to universal quantification

Dependent sum:       Σ(x : A), B(x)
  — a pair (a, b) where a:A and b:B(a)
  — corresponds to existential quantification

Product type:        A × B
  — pairs (a, b) with a:A, b:B
  — corresponds to conjunction (AND)

Identity type:       Id_A(a, b)
  — type of paths from a to b in A
  — refl_a : Id_A(a, a) is the trivial path
```

Homotopy equivalence

```
A ≃ B  :≡  Σ(f : A → B), isEquiv(f)

isEquiv(f) :≡
  Π(b : B), isContr(Σ(a : A), Id_B(f(a), b))
```

Two types are equivalent when there exists a structure-preserving map between them with a structure-preserving inverse. Equivalence is the formal criterion for ‘same structure, possibly different substrate.’

Higher Inductive Types (HIT)

Types with generators for both points and paths (and paths between paths). Example: the circle S^1 is generated by a point and a non-trivial loop. HITs allow the construction of types with prescribed homotopical structure — including types that model phase transitions and boundary conditions.

Type formation rules (inference rules inherited from HoTT)

Every type constructor comes with four rules:

Formation: under what conditions can the type be formed?

Introduction: how are terms of this type constructed?

Elimination: how can terms of this type be used?

Computation: what happens when introduction meets elimination?

These four rules constitute the rules of inference of HoTT. **HoTT-RO v2** inherits all of them without modification. The system adds no new inference rules — only new axioms (see below).

1.3 Axioms of HoTT-RO v2

HoTT-RO v2 has exactly two axioms. One is standard (inherited from HoTT). One is **new**.

Axiom 1: The Univalence Axiom (UA) — standard

$$UA : (A \simeq B) \simeq Id_u(A, B)$$

Statement: Equivalence of types IS identity of types. If two types are equivalent (there exists a structure-preserving map with a structure-preserving inverse), then they are identical as elements of the universe of types. Not merely 'similar.' Not 'corresponding.' Identical.

Origin: Vladimir Voevodsky (2010). Part of standard HoTT.

Ontological role: UA formalizes the relational constitution of identity. In the ontology, the identity of a configuration is determined by its relational structure, not by its material substrate. UA makes this precise: two configurations with equivalent relational structure are identical as types. This justifies the VCP's cross-substrate comparisons (octopus vs. corvid, bee vs. child).

What UA does NOT do: UA operates within a single universe level. It does not guarantee symmetry of mutual specification across levels. This is the gap that the second axiom addresses.

Axiom 2: The Axiom of Flat Mutuality (AFM) — new(!)

$$AFM : \Pi(n\ m : \mathbb{N})(A : U_n)(B : U_m)(e : A \simeq B),$$
$$MS(A, B) \simeq MS(B, A)$$

where the equivalence e operates in the common universe U_max(n,m) via canonical lifting, and where MS (Mutual Specification) is defined as:

$$MS(A, B) :\equiv \Sigma(e : A \simeq B),$$
$$(transport(ua(e)) = id_B)$$
$$\times\ (transport(ua(e)^{-1}) = id_A)$$

Statement: Mutual specification between two types is symmetric regardless of which universe level they inhabit. Neither side of a constitutive relation is prior.

Origin: New axiom proposed in this project (Lis/Claude, February 2026).

Why it is needed: Standard HoTT organizes types into a cumulative hierarchy of universes: $U_0 : U_1 : U_2 : \ldots$ The Univalence Axiom operates within one level. But the

ontology's central mechanism — Mutual Specification — requires that neither side of a constitutive relation be 'above' the other. AFM closes this gap: it guarantees flat mutuality across the universe hierarchy.

Consistency: AFM is consistent with UA, since univalence is itself symmetric ($e : A \simeq B$ implies $e^{-1} : B \simeq A$). AFM does not change any existing theorem of HoTT. It adds an ontological commitment: neither side of the mutuality can be at a higher universe level than the other.

Axiom history: AQE (withdrawn)

Version 1 of the formalization included a third axiom — the Axiom of Qualitative Emergence (AQE):

```
AQE : Π(κ : RelConfig),
  IT-Condition(κ) →
  Σ(P : IPType κ), isIrreducible(P)
```

AQE stated that crossing the Integration Threshold generates a new ontological type irreducible to its components. It was necessary because v1 modeled consciousness as a discontinuous phase transition (a 'jump').

AQE was withdrawn in v2. The reason: the ontology does not require consciousness to be a discontinuous jump. Nature builds increasingly complex networks — trees respond to damage chemically, octopuses distribute cognition across arms, bee swarms make decisions no individual bee makes. Consciousness is a gradient, not a light switch. Once the Integration Threshold was redefined as a topological region (see Derived Definitions below), AQE became redundant: Integrated Perspective emerges as a dependent type that deepens continuously as a configuration moves deeper into the region.

The result: **HoTT-RO v2** = MLTT + {UA, AFM}. Two axioms over Martin-Löf Type Theory: one standard (UA, which defines HoTT itself), one **new** (**AFM**). The simplest possible extension that captures the ontology's formal commitments.

Complete axiom set

```
HoTT-RO v2 = MLTT + {UA, AFM}

equivalently: HoTT + {AFM}
(since HoTT = MLTT + UA)

UA:  (A ≃ B) ≃ Id_U(A, B)
AFM: Π(n m : ℕ)(A : U_n)(B : U_m)(e : A ≃ B),
     MS(A,B) ≃ MS(B,A)
```

1.4 Rules of Inference

HoTT-RO v2 adds no new inference rules. All derivations use the standard type-theoretic inference rules inherited from HoTT:

For each type constructor (Π, Σ, ×, Id, HIT): formation, introduction, elimination, computation — as defined in the HoTT Book (Univalent Foundations Program, 2013).

Transport: Given a path `p : Id_u(A, B)` and a term `a : A`, transport produces a term `transport(p)(a) : B`. This is the mechanism by which identity paths move terms between types.

Function application, β-reduction, η-expansion: standard.

The fact that no new inference rules are added is important: it means that everything derivable in **HoTT-RO v2** is derived by the same logical machinery as standard HoTT. The only new content comes from the two axioms — which provide new starting points for derivation, not new methods of derivation.

1.5 Derived Definitions

The following definitions are not axioms — they are constructions built from the primitives and axioms above. They constitute the ontological vocabulary of the project.

Definition 1: Relational Configuration

```
RelConfig : Type
κ : RelConfig
```

A relational configuration is a type whose identity is constituted by its relational context (via UA). Specific configurations (a particular octopus, a particular bee swarm) are terms inhabiting this type.

Definition 2: Configuration Space

```
C :≡ Stability × Integration × Recursion

Each κ maps to a point in C:
  κ ↦ (s(κ), i(κ), r(κ))  ∈  [0,1]³
```

Stability `(s)`: the degree to which the configuration maintains structural coherence under perturbation. Derived from behavioral and physiological literature — memory retention, site fidelity, trial-to-trial consistency.

Integration `(i)`: the degree to which the configuration functions as a unified whole rather than as separable parts. Derived from network architecture, modularity indices, coordination measures.

Recursion / Self-modeling `(r)`: the degree to which the configuration models itself — generates an internal representation of its own relational structure. Derived from metacognition data, self-referential behavior, opt-out paradigms.

Critical note: s, i, r are not properties of the system. They are descriptions of the system's position in a relational parameter space. Each value is the arithmetic mean of three independent empirical sources. Each value is therefore a point estimate of a region (this follows from Radical Contextuality — see Definition 7).

Note on the formal gap: The types Stability, Integration, and Recursion are not constructed from the type-theoretic primitives above. They are posited as real-valued intervals [0,1], and the mapping from relational configurations (HoTT types) to numerical coordinates (points in $[0,1]^3$) is a measurement protocol, not a formal derivation. VCP is the bridge between the formal system and empirical data, but the bridge itself is not formalized in HoTT. This is stated explicitly: **HoTT-RO v2** provides the formal

justification for why cross-substrate structural comparison is meaningful (via UA and AFM). The numerical assignment of specific values to specific systems is an empirical procedure operating under that formal justification, not a theorem derived within it.

Definition 3: Integration Threshold Region (IT-Region)

```
IT-Region(κ) :≡
  s(κ) ≥ s_min
  ∧ i(κ) ≥ i_min
  ∧ r(κ) ≥ r_min
```

A configuration is in the IT-Region when all three parameters simultaneously exceed their respective minimum thresholds. This is a conjunction of three conditions — a three-gate test. The region is a subset of $[0,1]^3$.

Definition 4: Depth

```
Depth(κ) :≡
  min(s(κ)-s_min, i(κ)-i_min, r(κ)-r_min)
```

Depth measures how far inside the IT-Region a configuration sits. A configuration at the boundary has Depth = 0. A configuration deep inside has high Depth. Depth is determined by the weakest parameter — the bottleneck principle.

Definition 5: Proto-Phenomenal Capacity (PFC)

```
PFC :≡ ∂(IT-Region)
   = { κ : C | Depth(κ) = 0 }
```

The boundary of the IT-Region. The structural condition at which integrated perspective begins to emerge. Not consciousness — the capacity for consciousness. A topological definition: PFC is the boundary of a region, defined by the natural language of HoTT (types, paths, regions).

Definition 6: Integrated Perspective (IP)

```
IP(κ) :≡
  Σ(d : ℝ), (d = Depth(κ))
  × (d ≥ 0)
  × Vector(s(κ), i(κ), r(κ))
```

Integrated Perspective (the ontology's term for consciousness) is defined by the full vector, not just by depth. Two configurations with identical depth but different parameter ratios — say, high-s/low-r vs. low-s/high-r — generate structurally different forms of

Integrated Perspective. This is not a claim about *levels* of consciousness but about *forms* of consciousness. The vector carries this information; a scalar cannot.

Definition 7: Radical Contextuality (RC) as descent condition

Radical Contextuality — the claim that identity is constituted entirely by local relational context — is formalized through the descent condition in ∞-toposes (Lurie, 2009). In standard HoTT terms: for any configuration κ, its type is fully determined by the local diagram of types surrounding it. Change the relational context, and you change what κ is — not what it does.

Formal consequence: every VCP coordinate is a region, not a point. Because a configuration's identity is contextually constituted, and context varies, the 'position' of a system in $[0,1]^3$ is not a fixed point but a region whose center is the mean of independent sources. This is not a limitation of measurement — it is a structural consequence of the ontology itself.

Definition 8: Canonical Layering

```
Layer 1 (Reactive):
  Propagation without self-model.
  Available to all configurations.

Layer 2 (s-Directional):
  Propagation routed by stability structure.
  Requires s > s_min.

Layer 3 (r-Directional):
  Propagation evaluated by self-model.
  Requires r > r_min AND s > s_min.
```

Canonical layering is a structural dependency: Layer 3 requires Layer 2 as its scaffolding. Self-modeling (r-directionality) requires stability (s-directional scaffolding) to operate on. This is not a claim about numerical ordering of parameter values — it is a claim about structural dependency. The honest defense: no system in the VCP dataset has significant r without substantial s. The layering was discovered empirically, then verified deductively, then tested numerically (Simulation 14: PASS).

Definition 9: VCP (Vector Consciousness Prediction)

$$\mathrm{VCP}(\kappa) :\equiv (s(\kappa), i(\kappa), r(\kappa))$$

$$\text{Distance: } d(\kappa_1, \kappa_2) = \sqrt{[(s_1-s_2)^2 + (i_1-i_2)^2 + (r_1-r_2)^2]}$$

VCP is the measurement protocol derived from the formal system. It places configurations in $[0,1]^3$ and measures structural proximity by Euclidean distance. The formal justification for cross-substrate comparison comes from UA (structural equivalence is identity). The formal justification for flat comparison comes from AFM (no system is ontologically prior).

1.6 The Deductive Chain: From Axioms to Prediction

The complete chain from formal system to empirical prediction runs through nine steps:

Step 1. Ontological premises. Five pillars of the relational ontology (Relational Potential, Radical Contextuality, Ontological Emergence, Phase Transitions, Irreducible Otherness). These are philosophical claims, not formal theorems. They motivate the formal system but are not derivable within it.

Step 2. Formalization. HoTT-RO v2 translates four of five pillars into formal language. RP remains an inherent limit (see 1.7). RC becomes the descent condition. Ontological Emergence becomes the IT-Region structure. The UA and AFM axioms jointly formalize Mutual Specification.

Step 3. Configuration space. The three parameters s, i, r are derived as the minimal independent dimensions that characterize relational configurations. The derivation: s captures Gate I (stability), i captures Gate II (integration), r captures Gate III (recursion). Three gates, three parameters. The space $[0,1]^3$ follows from normalization.

Step 4. Empirical grounding. Each parameter for each system is derived from three independent empirical sources in the published literature. No parameter is assumed or estimated. The canonical dataset contains 11 systems × 3 parameters = 33 parameter values, each derived from 3 independent sources — approximately 99 source-level data points in total.

Step 5. Placement in parameter space. Each system is placed in $[0,1]^3$ as a point estimate (mean of three sources) representing a region (range of three sources).

Step 6. Structural comparisons. Euclidean distance between systems. Justified by UA (equivalence = identity, so structural distance is ontologically meaningful) and AFM (comparison is symmetric — no system is the standard).

Step 7. Derived predictions. From the formal structure of r-directionality: a system with high r should model itself sufficiently to evaluate difficulty and opt out of uncertain trials. The opt-out rate for Sepia officinalis, given its VCP coordinates (s=0.66, i=0.74, r=0.75), is predicted as ≈ 0.836.

Step 8. Falsification criteria. Opt-out rate < 0.60 falsifies the prediction. Opt-out rate in [0.76, 0.92] confirms it. The qualitative enrichment from dynamics (Book 2): opt-out should be directed (varying with novelty AND difficulty), not reactive (varying with difficulty alone).

Step 9. Dynamics validation. Six simulations (14–19) tested deductive claims from Book 2 against the canonical dataset. All six passed. No claim falsified. The deductive

chain from ontological premises through formal system to numerical validation remains unbroken.

1.7 Formalizability Map

Not everything in the ontology is formalizable. This is stated explicitly:

Mechanism	Status v1	Status v2	Note
Mutual Specification	PARTIAL	PARTIAL	UA within one level. AFM closes cross-level gap. Hierarchy itself remains.
IT — condition	OK	OK	Three gates as conditions on a type.
IT — mechanism	AQE needed	OK	Region replaces jump. AQE withdrawn.
Proto-Phenomenal Capacity	derived	OK	∂(IT-Region) — boundary of the region.
Radical Contextuality	OK	OK	Descent condition in ∞-topos.
Relational Potential	LIMIT	LIMIT	Inherent limit of every formal language. RP is meta-HoTT.

The RP limit: Relational Potential — the pre-categorical condition of possibility — corresponds to the metatheoretic structure of HoTT itself: the type formation rules that HoTT assumes before any type can be formed. In Martin-Löf's formulation:

```
Γ ⊢ A : Type    Γ, x:A ⊢ B(x) : Type
──────────────────────────────────────
Γ ⊢ Π(x:A), B(x) : Type
```

These formation rules are conditions of possibility of any type. They are not types themselves. RP corresponds to these rules: it is what makes the formal system possible, but it cannot be expressed within the formal system. This is analogous to Gödel's incompleteness: a system cannot encompass the conditions of its own possibility without regress. This is not a deficiency of **HoTT-RO v2** — it is an inherent limit of every formal language.

• • •

Part Two: How the Instrument Was Built

HoTT-RO v2 was not designed top-down. It was discovered through a sequence of structural isomorphism simulations. Seven simulations preceded the formalization: Ramanujan's mathematics (mock theta functions, Rogers-Ramanujan identities), algebraic topology, category theory, ergodic theory, knot theory, Monstrous Moonshine, and ∞-categories/∞-toposes (Lurie).

The ∞-category simulation was decisive. It revealed two STRONG structural isomorphisms: the Univalence Axiom with Mutual Specification, and the descent condition in ∞-toposes with Radical Contextuality. These were not analogies — they were structural correspondences at the level of formal definitions. This indicated that HoTT was not merely a convenient language but a *natural* formal language for the ontology.

Version 1 (February 2026) formalized three mechanisms with three axioms: UA, AFM, AQE. Version 2 withdrew AQE after recognizing that the assumption of discontinuous consciousness was an import from philosophical tradition, not a consequence of the ontology's premises. The Integration Threshold was redefined as a topological region, making AQE redundant. The result: a simpler, more honest system.

• • •

Part Three: How the Instrument Was Used

HoTT-RO v2 operates at the foundational level. It does not perform calculations directly. The numerical work uses standard arithmetic. What **HoTT-RO v2** provides is four specific formal guarantees:

Cross-substrate comparison (via UA): Two configurations are comparable if their types are equivalent, regardless of substrate. This justifies comparing an octopus to a corvid to a slime mold.

Identity as degree (via identity-as-path): 'Near' is a precise statement: the path between two configurations is short, has a specific direction, and has specific properties.

Flat mutuality (via AFM): No system in the VCP dataset is ontologically prior. The comparison is symmetric.

Continuous thresholds (via IT-Region): The boundary between proto-phenomenal and conscious is not arbitrary but topological. Systems near the boundary are formally near the boundary.

These guarantees supported nineteen simulations across eleven systems, a dataset of thirty-three parameter values derived from approximately ninety-nine independent source measurements, a falsifiable prediction (Sepia opt-out ≈ 0.836), and six dynamics validation tests — all passed.

• • •

Part Four: Suggested Applications Beyond the Original Project

HoTT-RO v2's structural features — relational identity, flat mutuality, continuous thresholds — are not exclusive to relational ontology.

Strong fit: Relational quantum mechanics (Rovelli)

Carlo Rovelli's relational interpretation (1996) claims that quantum states do not exist 'in themselves' but only relative to an observer. This is structurally identical to Radical Contextuality. Standard HoTT formalizes much of this, but its universe hierarchy introduces the asymmetry that relational QM rejects: the observer and observed system must be symmetric. AFM provides exactly this guarantee. A formalization of relational QM in **HoTT-RO v2** would capture what standard HoTT cannot: the structural claim that neither side of the measurement relation is prior.

Moderate fit: Developmental biology

A stem cell's identity is constituted by its relational context (signaling environment). Differentiation thresholds function like IT-Regions. The parallel is structural, not metaphorical. The limitation: developmental biology already has good models (Turing patterns, morphogen gradients). **HoTT-RO v2** would provide elegant re-description but uncertain added predictive value.

Exploratory fit: Distributed systems

In decentralized networks, node 'identity' is constituted by connections and transaction history. **HoTT-RO v2**'s path-based identity and flat mutuality could formalize aspects of distributed consensus. But this would use perhaps twenty percent of the apparatus. The fit is real but thin.

Where it does not apply

HoTT-RO v2 adds value only where: (1) identity is relationally constituted, (2) equivalence is structural, (3) flat mutuality is required. In domains with stable, intrinsic, absolute identity — classical mechanics, most of chemistry, engineering — standard mathematics works perfectly. The instrument is specialized.

• • •

Part Five: Limits and Honest Assessment

The RP limit is inherent. Relational Potential cannot be formalized in HoTT or any formal language without regress. **HoTT-RO v2** formalizes the manifestations of RP, not RP itself.

Mutual Specification remains partial. AFM flattens the universe hierarchy by decree, not by construction. A natively flat framework (certain versions of Cubical Type Theory) would be more satisfying but is not yet mature enough for applied work.

The formalization does not prove the ontology. HoTT-RO v2 provides a language in which claims can be precisely stated and tested. Whether the claims are true is an empirical question.

Classical mathematics distorts relational ontology. HoTT still starts with types (entities). A truly relational mathematics — one with relations as primitives, deriving objects — does not yet exist. **HoTT-RO v2** is the best available approximation.

• • •

References

References

Lis, W. (2025). **The Self-Experiencing Universe: A Manifesto for an Emergent Reality**. https://www.amazon.com/dp/8396865183

Lis, W. (2026). **The Self-Experiencing Universe Q&A**

https://www.amazon.com/dp/8396865175

Lis, W. (2026). Ho TT FORMALIZATION — VERSION 1 Homotopy Type Theory Univalent Foundations × Relational Ontology - https://archive.org/details/ho-tt-formalization-version-1-homotopy-type-theory-univalent-foundations-x-relational-ontology

Lis, W. (2026). Ho TT FORMALIZATION — REVISION V 2 - https://archive.org/details/ho-tt-formalization-revision-v-2

Lis, W. (2026). THE MATHEMATICAL FOUNDATION Ho TT And The Relational Ontology Of The Self Experiencing Universe https://archive.org/details/the-mathematical-foundation-ho-tt-and-the-relational-ontology-of-the-self-experiencing-universe

Lis, W. (2026). Dynamics Validation Series: Simulations 14–19 https://archive.org/details/dynamics-validation-series-sim-14-19-full-technical_202604

Lis, W. (2026). COHERENCE STUDY Relational Ontology × Formal Mathematical Systems

https://archive.org/details/coherence-study-relational-ontology-x-formal-mathematical-systems

Lis, W. (2026). STRUCTURAL ISOMORPHISMS ∞ Categories And ∞ Toposes (Lurie) × Relational Ontology - https://archive.org/details/structural-isomorphisms-categories-and-toposes-lurie-x-relational-ontology

Univalent Foundations Program (2013). Homotopy Type Theory: Univalent Foundations of Mathematics. Institute for Advanced Study.

Lurie, J. (2009). Higher Topos Theory. Princeton University Press.

Martin-Löf, P. (1984). Intuitionistic Type Theory. Bibliopolis, Napoli.

Voevodsky, V. (2010). Univalent Foundations of Mathematics. IAS Lecture.

Rovelli, C. (1996). Relational Quantum Mechanics. International Journal of Theoretical Physics, 35(8), 1637–1678.

Gödel, K. (1931). Über formal unentscheidbare Sätze der Principia Mathematica. Monatshefte für Mathematik.

© 2026 Waldemar Lis. All rights reserved.

Full archive: archive.org/details/@not_foryou